

**“Preserving the Finger Lakes for the Future”  
A Prototype Decision Support System for Water Resource  
Management, Open Space, and Agricultural Protection**

**Annual Report 2003 - 2004**

**Submitted to:**

**National Aeronautics and Space Administration**

**December, 2004**

## **ANNUAL PROGRESS REPORT OF RESEARCH**

### **RESEARCH GRANT**

**Name and address of recipient:**

Attn: Robert Brower  
Regional Applications Center for the Northeast (RACNE)  
Cayuga Community College  
199 Franklin St., Suite 300  
Auburn, NY 13021-3025

**Grant Number NAG13-02059**

**For research entitled:**

"Preserving the Finger Lakes for the Future"

A Prototype Decision Support System for Water Resources Management, Open Space and Agricultural Protection.

**This is an Annual Progress Report for the period 9/26/03 to 9/25/04.**

**Name of Principal Investigator:**

Robert Brower

**For this annual progress report of research, the following summary of significant accomplishments during the above mentioned period is hereby submitted.**

## **Table of Contents**

<b>ANNUAL PROGRESS REPORT OF RESEARCH .....</b>	<b>I</b>
<b>1. INTRODUCTION .....</b>	<b>3</b>
1.1 APPLICABILITY TO THE TWELVE NASA EARTH SCIENCE APPLICATION AREAS .....	3
<b>2. PROJECT GOALS AND OBJECTIVES .....</b>	<b>4</b>
2.1 DEFINE THE FUNCTIONAL NEEDS OF THE PROTOTYPE .....	4
2.2 DERIVE THE SPATIAL DATA REQUIREMENT .....	6
2.3 DESIGN AND DEVELOP THE PROTOTYPE SYSTEM .....	9
2.4 TEST AND EVALUATE THE SYSTEM .....	11
2.5 UNDERTAKE FOLLOW-ON EDUCATION AND TECHNOLOGY TRANSFER EFFORTS .....	12
<b>3. FINANCIAL SUMMARY .....</b>	<b>13</b>

## **1. INTRODUCTION**

This report summarizes the activity conducted under NASA Grant NAG13-02059 entitled "Preserving the Finger Lakes for the Future" A Prototype Decision Support System for Water Resources Management, Open Space and Agricultural Protection, for the period of September 26, 2003 to September 25, 2004. The RACNE continues to utilize the services of its affiliate, the Institute for the Application of Geospatial Technology at Cayuga Community College, Inc. (IAGT), for the purposes of this project under its permanent operating agreement with IAGT. IAGT is a 501(c)(3) not-for-profit corporation created by the RACNE for the purpose of carrying out its programmatic and administrative mission.

The "Preserving the Finger Lakes for the Future" project has progressed and evolved as planned, with the continuation or initiation of a number of program facets at programmatic, technical, and inter-agency levels. The project has grown, starting with the well received core concept of the Virtual Management Operations Center (VMOC), to the functional Watershed Virtual Management Operations Center (W-VMOC) prototype, to the more advanced Finger Lakes Decision Support System (FLDSS) prototype, deployed for evaluation and assessment to a wide variety of agencies and organizations in the Finger Lakes region and beyond. This suite of tools offers the advanced, compelling functionality of interactive 3D visualization interfaced with 2D mapping, all accessed via Internet or virtually any kind of distributed computer network.

### **1.1 Applicability to the Twelve NASA Earth Science Application Areas**

By design, the FLDSS and its concepts endeavor to be applicable to many areas of concern in the Finger Lakes region. As such, the integrated and related technologies of the FLDSS fit well into several of the twelve Earth Science Application areas. Of these, two are most prominent (Water Management and Agricultural Efficiency) and benefit from the current structure of the prototype.

**Water Management** - The Finger Lakes region enjoys an abundance of high quality water in its vast network of lakes, rivers, streams and groundwater resources. Concern for the wise use of these resources is a focal point of this project. In fact, IAGT personnel have adopted the science and philosophy that surface and ground water are a single resource. Therefore, one of the original goals of the project was to identify probable areas of surface and ground water interaction. Though reliable groundwater data has proven to be limited for this region, estimates of groundwater locations vulnerable to infiltration have been developed through modeling [section 2.2 (8)]. Combined with other water resource data layers, the FLDSS strives to provide a new way to view the environment of the region and expand its scope and understanding beyond the boundaries of surface watersheds.

**Agriculture Efficiency** - Agriculture is a primary industry in this region and is therefore a primary focus of this project. Through the application of models, geo-processing [section 2.2 (8)] and various data sets, the IAGT staff is developing a better understanding and a regional view of agricultural protection areas, as well as the conservation of open space. Further, as understanding weather patterns is vital to enhanced farming practices, the integration of near real time weather information into the FLDSS has been investigated, and direct links to near real time Internet weather sites have been created [section 2.3 (4)]. Further, the ability to track storm events that can cause personal, community and economic damage (for example, snow and ice

storms) continues to be pursued and would be an extremely valuable tool fitting well into the Disaster Management area.

**Other Application Areas** - As the project has unfolded, IAGT sees the potential or has begun to apply the FLDSS and/or its core technologies to at least the following areas: Coastal Management; Homeland Security; Public Health; and Ecological Forecasting. As the developing technology integrates the power of traditional Geographic Information System (GIS) mapping and analysis with the compelling use of 3D interactive visualization, it is apparent that the many tools inherent in the prototype can be used to address a wide variety of issues. By its nature, the project and technology also support and promote data sharing, agency collaboration and the integration of remote sensing and GIS data. These areas of the project have been a primary focus of the 2003 – 2004 year, and will continue to be in the final grant year. All of these attributes form a solid basis for use in a number of the application areas

## **2. PROJECT GOALS AND OBJECTIVES**

### **2.1 Define the Functional Needs of the Prototype**

- 1) An initial set of functional needs for the prototype will be defined by the IAGT project staff.
  - The initial functionality of the prototype was determined early in the project and includes several primary requirements that form the basis for its ongoing development. These primary requirements have continued to form the backbone and general philosophy of the project and bear repeating:
    - The integration of 2 dimensional GIS mapping interface with interactive 3 dimensional visualization technology.
    - The ability to be deployed over the Internet or network providing access for and evaluation by a Stakeholder Group.
    - Inherent flexibility in the prototype to allow the use of a wide variety of data, as well as applicability to many types of projects.
    - The desire to develop a Decision Support System that could be used as a common set of tools that stakeholders in a variety of disciplines could access and use to aid in wise decision making in the Finger Lakes region.
  - Integral to the project has been the continued cooperative work with two other agencies: The Central New York Regional Planning and Development Board (CNYRPDB), and the Cayuga County Planning Department (CCPD). The CNYRPDB is conducting work funded through a grant from Housing and Urban Development (HUD) for the conservation of open space and agricultural areas. A logical synergy exists between the two projects on technical, policy and jurisdictional levels. The projects are running on parallel tracks with support from the CCPD for data development and technical assistance. Some success has been realized through meetings between CNYRPDB, CCPD and local town boards to enhance local understanding of the advanced planning techniques available to them integrated with new technological tools, including GIS and the FLDSS. Additional meetings with other towns and organizations look promising as well. As a coordinating vehicle, the Finger Lakes Water Resources, Open

Space and Agricultural Conservation Project (FLWROA) continues to have regular meetings consisting of CNYRPDB, CCPD and IAGT to oversee progress of the various facets of the related work and to share ideas, information and task assistance as needed.

- 2) Water Resource Priority Protection Areas (WREPPA's) will be designated.
  - As review, these areas will be designated based on the coincidence of agricultural protection areas, ground/surface water interaction, significant viewsheds and open space, and a variety of other important environmental factors including wetlands, NYS priority water bodies and others. The majority of the data sets and analyses for the creation of derivative data sets required for the identification of WREPPA's for the prototype FLDSS have been completed. Staying within the scope of the project, the majority of these falls within the prototype area (Owasco Lake Watershed), but also includes some applicable to the greater Finger Lakes region. This will provide users of the system with a number of data layers and tools that can be used to identify, review and analyze WREPPA's. Further, a sample analysis resulting in an example data layer of WREPPA's will be developed for inclusion in the system. See section 2.2 for more detail about data needs and development.
- 3) A first version of the W-VMOC will be implemented based on the defined initial functional management requirements.
  - A first version of the W-VMOC has been completed and after detailed testing and review allowing the addition of greater functionality, has evolved into the prototype FLDSS as described throughout this report.
- 4) A stakeholders group will be formalized to review, amend, and react to W-VMOC functionality.
  - A Stakeholder group was picked representing all levels of government for the Finger Lakes region. These organizations and agencies were invited to a day long facilitated information gathering meeting on October 27, 2003. Professional facilitators lead the participants from over 25 agencies and organizations through traditional information gathering techniques to identify challenges and opportunities for the wise use of the Finger Lakes region. A live demonstration of the prototype was given including a hypothetical application for watershed planning, followed by additional facilitations to help determine how the prototype technology can be applied to address these challenges. This meeting formed the starting point for the development of a comprehensive hands-on Stakeholder Evaluation process of the prototype (section 2.4).

- 5) Stakeholder feedback will be derived from this group and summarized in a Management Requirements Guide.
  - The resulting information gathered from this meeting combined with other information from stakeholders, was reviewed and analyzed and continues to form a basis for the continued development of the prototype (see below).
- 6) **DELIVERABLE:** Implementation of an initial prototype W-VMOC, to be verified by NASA by accessing the prototype via Internet.
  - Implementation and provisional access to the prototype has been completed. Access to and demonstration of the W-VMOC prototype as warranted will be provided to NASA for review and comment.
- 7) **DELIVERABLE:** Completion of a Management Requirements Guide.
  - The Management Requirements Guide will be completed in the 4<sup>th</sup> quarter of 2004 based on information derived from Stakeholder feedback from demonstrations, hands-on evaluations, prototype testing by IAGT staff and external testing assistants. As planned, the document will serve as a primary resource guide to staff for the continued development of the prototype decision support system.

## **2.2 Derive the Spatial Data Requirement**

- 1) Taxonomy of spatial data will be developed, based on the Management Requirements Guide.
  - The taxonomy of spatial data was developed via the creation of a "data matrix" reflecting data needs, sources and pertinent facets of the program for the varying data types. This was accomplished in part through review of other DSS's and the IAGT staff's extensive knowledge of environmental and regional mapping. Equally important, however, was determining the data needs of the project based on general system/project issues as expressed by Stakeholder review (see appendix – Management Requirement Guide) and the models and analyses required to generate derivative data sets. However, interpreting this information and determining what works best in the areas of modeling and other geo-processes has dictated several revisions of the data needs scheme. The final data requirements report is scheduled for completion in the first quarter of 2005 (see below).
- 2) A review of remote sensing instruments to supply such spatial data will be undertaken.
  - A preliminary review of available remote sensing instruments and the data products they can produce for the study region as been completed. A final version of this information will be included with the Data Requirements report.
  - After reviewing various data products and needs, low level orthophotography was used to delineate a detailed land use/land cover base for the prototype area, rather than satellite imagery. However, investigations into the viability of classifying impermeable surfaces over time, as a possible measure of regional growth in the

Finger Lakes region have been initiated. Several different satellite derived products will be reviewed for applicability in this effort. Further, an investigation into remotely sensed water quality data (below) for the correlation of satellite imagery as a measure of water clarity will be completed in the spring of '05.

- 3) A review of available GIS data will be undertaken from state, local, and commercial sources.
  - A comprehensive review of these data sets has been completed (below).
  - To obtain the most reliable data for the local area, funding was provided to the Cayuga County Planning Department for the development of a variety of data sets to be used for base mapping, modeling and task specific data needs. This effort has been completed and the data sets have been integrated into the FLDSS.
- 4) A review of underwater sampling data and other in situ monitoring data from various research institutions and academic activity where available will be undertaken and incorporated in the prototype design.
  - In cooperation with a local lake association and others, IAGT successfully funded and oversaw the deployment of an automated, robotic buoy in Owasco Lake. This buoy is similar to several others used in other New York State waters, including neighboring Cayuga and Skaneateles Lakes. The buoy has a group of sensors mounted beneath it. These can be remotely triggered or programmed to be lowered and raised through the water column to take measurements and readings of water characteristics at a wide variety of depths. This provides a more realistic general description of the characteristics of the lake than samples taken at a single depth. The captured data is then transmitted to shore for processing. Finally, the buoy will also include an above water "weather station" that can also transmit current weather conditions to shore, providing the potential for access to near real time weather conditions on the lake via the Internet or other means. An initial use of the buoy's collected data will be to investigate correlation with satellite data (above).
  - Academic institutions including Cornell University and Hobart William Smith Colleges (HWS) have been contacted to discuss water quality monitoring and exchange ideas and information. One prominent result of these discussions was a contract with HWS to collect detailed bathymetric data for Owasco Lake, using sonar technology linked to a Global Positioning System. Efforts are underway to incorporate this data into the 3D visualization technology utilized in the FLDSS. It is anticipated that dialogs with HWS and other institutions will continue with the hope of other future partnerships and projects.



- 5) A matrix of data needs and sources and a list of databases will be created.
  - A draft data matrix describing required project data types and the related sources, scales and other descriptors has been created and revised, and will be included in the Data Requirements report. The matrix helps to codify the data needs of the FLDSS project, and will help in the planning of future projects.
- 6) Preliminary costs to deploy and sustain the system will be projected.
  - This task will be completed upon completion of the full data review and finalization of the data matrix, taking into account the issues raised through the stakeholder process. Additional information gained through systematic deployment and evaluation of the FLDSS (section 2.4) will be carefully reviewed as input for this effort.
- 7) Prototype design will be revised to accommodate these considerations, as practical
  - The development of the prototype has been determined in part by the findings in this section.
- 8) Development of Derivative Data Sets
  - As the FLDSS project has progressed, the required data needs have become clearer. In several instances, data sets for the prototype area (and beyond) are unavailable to fill these needs. As a result, various existing models and processes used to derive certain data sets were adapted for use in a geo-processing environment; the resulting data sets are included in the prototype FLDSS. Primary examples of these include: DRASTIC (Environmental Protection Agency), a groundwater vulnerability model; the Land Evaluation and Site Assessment model (LESA, Natural Resource Conservation Service), a process providing a ranking of land value for agricultural use; the Riparian Buffer Delineation Equation (RBDE), for determining buffer zones along water courses; and sophisticated GIT processing for developing viewable areas and the corresponding land classifications for viewshed analysis.
- 9) Terrain Files/3D Visualization
  - Efforts have been ongoing to develop the best 3D terrain and visualizations for the FLDSS. To date IAGT personnel have created terrains for the prototype Owasco Watershed with various degrees of vertical exaggeration, and a experimental terrain for the entire Finger Lakes region. A prototype landscape depicting varying heights for given land use types has also been created. Currently under development are terrain models for the Owasco Lake watershed including Owasco Lake's bathymetry and more current imager, and terrains for neighboring Cayuga Lake watershed.

**10) Expression of Data Quality**

- Scheduled for completion in the first quarter of '05 are a report and mechanisms to assess the quality of data used in the FLDSS. Included in this effort are: meta data for all data sets; sensitivity analyses for data layers derived through modeling and other processes; and an easily understood level of reporting that describes the data quality that can be accessed directly from within the FLDSS. An attempt will also be made to develop a graphic "data confidence bar" that will provide general guidance to the user as to the applicability of a given data set.

**11) DELIVERABLE: Completion of a Data Requirements Report.**

- This report is anticipated to be completed in the first quarter of 2005 and will reflect on the components described in this section (2.2). It is envisioned that the data matrix and associated report will serve as a primary source for IAGT staff to refer to as a valuable resource for the project as well as future endeavors in DSS technologies. This report will be made available to NASA for review and comment upon its completion.

**2.3 Design and Develop the Prototype System**

- 1) Create an end-to-end prototype W-VMOC for identifying environmentally sensitive areas.
  - This work is ongoing as described and supported by the tasks detailed in this document. The project has proceeded well and the W-VMOC has "matured" into a functioning prototype FLDSS.
- 2) Fusion with a growth model for gauging threats to sensitive areas will be considered.
  - The overall rationale for this work can be described simply. Once environmentally sensitive areas are determined, they can become parameters driving the input for growth modeling. That is, these become clearly defined suggested areas that should receive special attention, to be monitored closely for development pressures, or to be delineated as limited or no growth areas.
  - Including the input and suggestions of the CYNRPDB and CCPD, a variety of growth models has been assessed for applicability to the project. IAGT envisions integration into the Finger Lake Decision Support System representative scenarios from at least two models. The rationale for the use of more than one is that no one model can satisfy the needs of every location and application. The "Uplan" model provides results describing a general ranking of probably of growth areas. "Community Buildout" develops a set of points representing the fully built out density (not actual locations) of buildings for a given area. Thus IAGT envisions a selection of scenarios from the models to provide a strong measure of flexibility in the final prototype, giving the user an idea of growth given existing conditions as well as suggested scenarios taking into account environmentally sensitive areas.

- 3) The watershed will be searched for environmentally sensitive areas.
  - A primary functional requirement of the prototype FLDSS is to enable the overlay and visualizations of data sets revealing WREPPA's [section 2.1 (2)]. As such, this capability and the data to support it have been built into the prototype and is continually re-assessed and tested. It is a goal to have these facets in place to allow users of the prototype to identify WREPPA's for a given area of interest interactively. Thus the user can choose the levels of sensitivity for any given parameter from the data available, and display the results. To support this idea, IAGT staff will develop a sample data set that describes the results of one example of WREPPA identification.
- 4) Integration of weather data and information.
  - The integration of real time and near real time weather information is also a goal for the project. As a proof of concept, NEXRAD data was converted and modified into rough representations of cloud patterns moving through the region and displayed in the W-VMOC. For the FLDSS, a layer of points representing near real time weather data gathering sites has been developed. These are "hot linked" to web pages broadcasting near real time weather information, maintained by the National Weather Service and others.
  - Similarly, links near real time data from transmitted from the robotic buoy(s) [section 2.4 (4)] deployed in Owasco and other area lakes will be available in the FLDSS.
- 5) Web Site
  - A dedicated FLDSS Internet Web site will be developed that provide access to more comprehensive information about the FLDSS project to the general public, as well as a more intuitive interface and access to the FLDSS application.
- 6) **DELIVERABLE:** A second version of the W-VMOC will be implemented in a WAN with a 3D visualization portal.
  - The second version of the W-VMOC, has in essence become the prototype Finger Lakes Decision Support System as described herein. In this form, the current prototype includes the accomplishments of enabled WAN or Internet implementation and a powerful 3D visualization portal. As these milestones have been met, IAGT initiated a controlled deployment of the technology to assist in its development. That is, select stakeholders are being asked to utilize the technology and report on it's applicability to real life situations, ease of use, technological hurdles etc. See section 2.4 (below) for a more detailed description of these efforts.

## **2.4 Test and Evaluate the System**

- 1) The technology will be tested by utilizing both ground-truth and high accuracy reference data.
  - Throughout the development of the prototype, especially for the data development components, an emphasis has been on utilizing the best data available. This has included the use of low level digital orthophotography. This imagery has been used to create the 3D terrain visualizations, but has also been used as a basis for data development. In fact, a detailed land use land cover data set was digitized directly from high resolution imagery of this type.
- 2) Evaluate the capacity for system use for threat assessment in relation to WREPPA's.
  - This has been an ongoing effort as the prototype has been developed. As data sets were created or derived for this process through modeling, the resulting rankings were reviewed for their applicability in determining WREPPA's and what this information tells the user. Further, this is a primary area in which IAGT staff hopes to continue to gather data based on evaluation site feed back.
- 3) Evaluate the overall performance of the system.
  - Overall performance of the system is monitored nearly continually by IAGT staff and other users. The use of the system by stakeholder evaluators at remote sites has provide a great deal of information as to it's performance in different remote locations. Issues including network firewalls, bandwidth, wireless networks, and coincident use by various sites have all been, and will continue to be, reviewed. Formal, timed, in-house tests have also been run to gather data on access and response time of the VMOC core technology that drives the FLDSS.
- 4) Project the long-term data support requirements.
  - Information for long-term data support requirements is continuing to be gathered and assessed as the project proceeds. Through the final grant year, a focus will be on attempts to build partnerships and some level of invested user base – the primary key to making this a reality. The hope is that as these relationships are built, long-term regional data needs will be clearly delineated and plans put in place for an agency(ies) to house, maintain, fund and share their data. This data can then be accessed by all users through the use of the prototype's remote data access capabilities (currently utilizing the ESRI ArcIMS technology)
- 5) Stakeholder evaluations will be undertaken
  - IAGT staff provided access to the prototype for a small group of 5 evaluation sites, at the county, regional and state government levels. Individual evaluations were submitted back to IAGT, supplemented by a conference call of all the participants. In addition, ongoing less formal communications have been maintained with these sites to try to get the best understanding of how the prototype functions as well as how it can be best presented or modified as necessary to fit into an agency's daily work flow. Plans are in place to continue these efforts and to fine tune and expand the evaluation sites. This will include

additional and/or improved training methods and potentially a focus group of existing and future evaluators.

**6) DELIVERABLE: Completion of a Test and Evaluation Report.**

- This is envisioned to be a descriptive summary of the tasks listed above. In addition, a white paper investigating long term sustainability of the Prototype will be completed. The information and insights gained from this task (2.4), combined with an analysis of how the IAGT can best move the technology forward to other projects will be the basis for this paper. Topics to be include are, but not limited to: ongoing software upgrades and modifications; long-term maintenance of data; data warehousing; maintenance and update of server hardware; and the economics and funding acquisition necessary to enable all of these tasks.

**2.5 Undertake Follow-on Education and Technology Transfer Efforts**

**1) Present the system to the Northeast Affiliates Group, GIT workshops and conferences.**

- Presentations describing the project and prototype system have been given to members of the Northeast Affiliates Group, and at a wide variety of conferences and workshops. IAGT will continue to present and demonstrate the prototype as it evolves as often as the opportunities arise.
- A condensed version of the FLDSS has also been developed that focuses primarily on the 3D visualization components. This format, referred to as a "kit", has been created on a global model. The user or observer can start "flying" in space while observing the Earth and then move increasingly closer to the prototype study area, reviewing nested imagery of finer and finer resolution. Utilizing a variety of satellite imagery as well as low level aerial imagery, this version of the FLDSS has been well received at conferences and demonstrations.

**2) National Association of Counties; Hire a GIT Extension Specialist: Water Resources.**

- IAGT is maintaining a strong relationship with the National Association of Counties (NACo). The position of GIT Extension Specialist was created, filled and funded through this grant. The Extension specialist is located at the NACo offices in Washington, DC, and aids and enhances the presentation of the VMOC/FLDSS technology and applications at the national and county levels, as well as performs other tasks for NACo. To enable coherency and consistency with the project, a regular reporting and communication mechanism has been devised between the GIT Extension Specialist and the FLDSS project manager.